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MISCELLANEOUS PAPERS.

Fungous Diseases Liable to be Disseminated in Shipments of Sugar Cane . ETHEL C. FIELD

The Work of the Yuma Experiment Farm in 1912 . . . . . W. A. PETERSON

Directions for Collecting Plants . . . . . P. L. RICKER

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[Cir. 126—A]

FUNGOUS DISEASES LIABLE TO BE DISSEMINATED IN SHIPMENTS OF SUGAR CANE.[1]

By Ethel C. Field, *Scientific Assistant, Office of Cotton and Truck Disease and Sugar-Plant Investigations.*

INTRODUCTION.

Sugar cane in the United States has been relatively free from fungous diseases so far, but as the industry grows it is to be expected that foreign diseases will creep in along with imported sugar cane for propagation, as has already happened in a few instances. Every effort should be made to eliminate these diseases and to prevent the further introduction of new ones. Since inspection is not adequate, the most feasible method of dealing with sugar-cane imports is to grow them under quarantine. Mr. E. J. Butler, imperial mycologist of India, who is familiar with cane diseases in Bengal, makes practically the same suggestion respecting imports into that country. He states in his discussion of the red-rot stem disease that "experience has shown—explain it how we may—that new importations are particularly liable to fall a prey to disease. Where a foreign variety is introduced it will probably be better to grow it for some years in seed beds with careful cultivation before planting out on a large scale." [2]

A brief description of some of the most important diseases is here given, being mostly compiled from foreign publications. The various leaf diseases have not been included, although the annual loss caused by them is not inconsiderable.

RED-ROT OF THE STEM.

Red-rot of the stem (*Colletotrichum falcatum* Went) was first detected by Dr. F. A. F. C. Went in 1892 at the Tjomal factory in Java. He described the disease later under the name of red-smut, which has since been supplanted by the above name on account of the presence of a true smut on sugar cane. The disease has become widely distributed over cane-growing regions, having been reported from Queensland, Bengal, Madras, Madagascar, Hawaii, and the West

[1] Issued May 10, 1913.

[2] Butler, E. J. Fungous diseases of sugar cane in Bengal. Memoirs, Department of Agriculture, India, Botanical Series, v. 1, no. 3, p. 22, 1906.

Indies. More recently (1908) it was discovered by Dr. C. W. Edgerton [1] at Audubon Park, New Orleans. It has also been reported from Florida and Georgia.

It is difficult to estimate the amount of damage caused by red-rot, since this does not consist of a loss in stand alone; but, as shown in experiments conducted by Mr. Butler [2] in Bengal, the most serious loss consists of a decrease in sucrose content with an increase of glucose brought about through the action of the parasite.

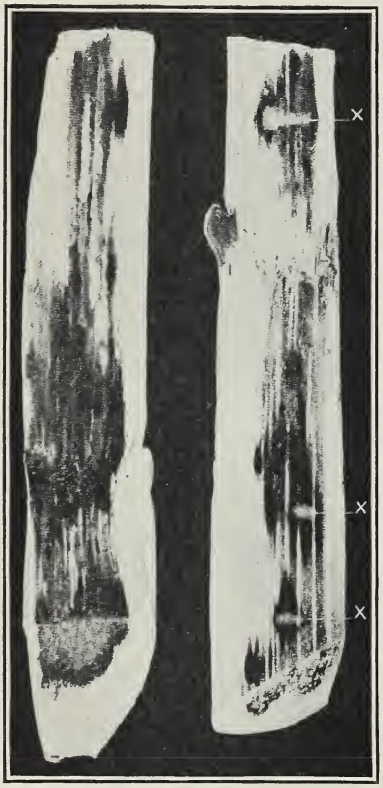

FIG. 1.—Red-rot of sugar cane, showing white spots (x) in center of red blotches. (After Lewton-Brain.)

The presence of the disease in the field usually does not become evident until the cane is approaching maturity. A slight drooping of the upper leaves then becomes noticeable. The leaves wither at the tip, advancing along the margin of the leaf, leaving a green center. Finally the whole crown droops, although the stalk remains apparently healthy. According to Butler the diseased plants have the same appearance as those affected by drought, except that green and withered stalks may be seen arising from the same stool. In a bad attack these withered stalks become light in weight, fall over, and contain practically no juice.

If a stalk is split open at the base during the early stages of the disease, the fibrovascular bundles may be seen as reddened streaks, which gradually increase in diameter, spreading outward into the neighboring tissue. Later, white blotches consisting of dead cells filled with air may be found in this reddened area. (See fig. 1.) The disease advances upward toward the tip, the tissue finally becoming dark to blackish in color. If the stool is examined it will be found that the discoloration of the stalk extends downward into the cutting and may be traced from here into other stalks which outwardly seem perfectly normal. The fungous spores are usually

[1] Edgerton, C. W. The red-rot of sugar cane, Louisiana Agricultural Experiment Station, Bulletin 133, 22 p., 4 pl., 1911.

[2] Butler, E. J. Fungous diseases of sugar cane in Bengal. Memoirs, Department of Agriculture, India, Botanical Series, v. 1, no. 3, 53 p., 11 pl., 1906.

formed on the dry sugar cane at the nodes or in sunken areas on the internodes.

There has been considerable doubt among investigators as to the manner in which the disease is distributed. Some attribute its spread entirely to the agency of cane borers. Dr. Edgerton states that in Louisiana the infection takes place chiefly through the agency of the moth borer (*Diatraea saccharalis*). In an examination of 55 borer cases, he found that 25 were infected with red-rot, 25 not diseased, and 5 doubtful.

Mr. Butler concludes from his observations that the disease is carried in the sets themselves. He found that the yellow Bourbon cane which came from infected districts gave diseased shoots, while the same variety obtained from disease-free regions and grown adjacent to the former plants produced healthy shoots. It would seem from this experiment that the use of diseased stalks for cuttings is the chief source of infection, although cane borers undoubtedly spread the disease to some extent in those fields already infested with spores from the previous season's growth.

While the disease may be detected in many cases by inspection, an absolute guaranty of disease-free cane could not be given. Mr. Butler also says that—

> Unfortunately, even with the greatest care it is not possible to eliminate diseased sets entirely, for I have obtained cultures of the fungus from sets passed by a particularly careful man, and the reddening does not always show at the cut ends.

And in speaking of the red discoloration of the tissue, which is considered the chief diagnostic character, he states that—

> There is no peculiarity in this discoloration that I have been able to find which serves to distinguish it in all cases from the reddening due to other causes.

Control.—Selection of resistant varieties and selection of "seed" are recommended for controlling the red-rot.

ILIAU.

Iliau (*Gnomonia iliau* Lyon) is a disease apparently peculiar to Hawaii, where it is said to have been known since the beginning of the sugar industry. Although the disease has been recognized for many years, it was not until 1912 that the entire life history of the causal organism was worked out and published.[1]

Dr. Lyon considers that far greater losses to the sugar planters in Hawaii have occurred from this disease than that caused by all other fungoid diseases combined. The following instances of loss are quoted from his bulletin:

> The manager of one plantation estimated that fully one-half of the shoots in a 200-acre field of 4-months-old plant cane had been killed out by iliau. His estimate was

[1] Lyon, H. L. Iliau, an endemic cane disease. Report of Work of the Experiment Station, Hawaiian Sugar Planters' Association. Pathological and Physiological Series, Bulletin 11, 32 p., 10 fig., 1 pl., 1912.

made at a time when the disease was at its height in the field. At a later period, during warm weather, this cane recovered rapidly, the stand being greatly augmented by new shoots. When the field was finally harvested the yield in sugar was about 20 per cent less than the average amount which this field could be expected to produce. The loss in this case amounted to a little over a ton of sugar on each acre. As no other disturbing factors appeared during the growth of this crop, the loss can very reasonably be ascribed entirely to iliau.

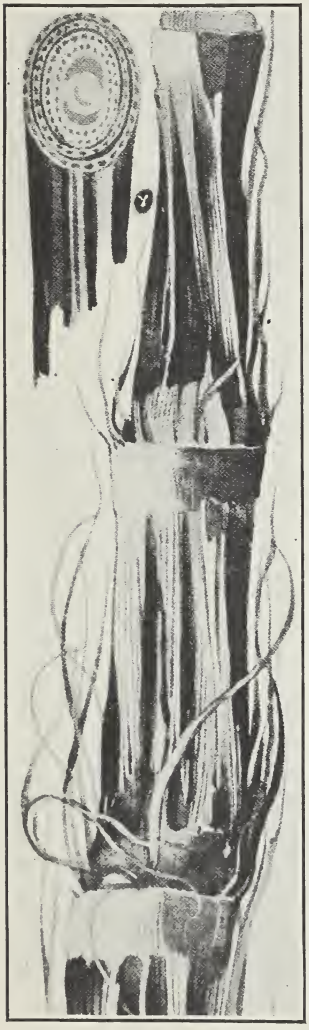

FIG. 2.—Iliau disease of sugar cane after an attempt to remove the leaves. (After Cobb.)

We have seen several cases where iliau has killed all of the stools over small areas of plant cane and one case where it effectually destroyed the cane over an area of 15 acres. We have seen many instances where the disease has killed from one-fourth to one-half of the primary shoots in large fields, our estimates for several cases being based on careful counts made in various parts of the affected areas.

Iliau is a Hawaiian expression meaning "tight skin" or "hidebound," having reference to the manner in which the leaf sheaths are firmly held together around the stem by the fungous mycelium. Any attempt to remove the leaves is met with considerable resistance. The fungus gains an entrance into the tissue of the cane at the leaf bases usually below the surface of the ground and from here makes its way into the leaf sheaths, working upward and then inward. The leaves whose sheaths are diseased soon die but do not fall off, as they are tightly cemented to the sheaths within. (See fig. 2.) On young cane this tight case prevents the shoot from elongating and thus eventually kills the terminal growing point. If the stem or shoot outgrows the mycelium, i. e., before the fungus has penetrated the inner sheaths, the disease does little harm. The fungus can make material progress only in young and tender tissues, and even if it has entered the stem its growth is checked by the normal hardening of the tissues. The dead leaf sheaths are pinkish brown in color and the rind, if any growth has been made, is deep bluish gray.

The imperfect form of this fungus (Melanconium) is the one most commonly met with on the diseased shoots. It belongs to the same

genus as the fungus causing rind disease of cane. There should be no confusion in distinguishing the two diseases in the field, the one being a vigorous parasite attacking only young shoots, while the other is a saprophyte found on cane killed from some other cause. The spores are formed in pustules usually within the tissue of the stem or the inner leaf sheaths and are not released until the stem disintegrates. So long as the shoot remains dry the pustules remain intact, but when moistened the sheaths loosen and the spores are freed.

The disease flourishes only during damp, cool weather and then only on young shoots. Fields in which the cane is more than half grown are not affected, the disease being confined in that case to the young shoots or suckers.

Inspection of seed sugar cane for this disease would be inadequate, since the disease is usually not evident on mature cane. Spores of the fungus might be carried on the surface of the lower portions of the stalks which had outgrown the disease or might find lodgment on healthy cane coming from infected areas and the disease be thus carried.

Control.—Thorough preparation of the soil previous to planting is recommended in controlling the disease, since an exposure of the spores and mycelium to the sun for a few hours effectually destroys them.

GUMMING.

Gumming (*Bacterium vascularum* (Cobb) Greig-Smith), a disease of the fibrovascular bundles of sugar cane, was first described in 1893 by Dr. N. A. Cobb [1] from the Clarence River district of Australia. It is also present in Mauritius, Java, and Brazil. While this trouble has so far been easy to control in infected regions it might become far more serious if introduced into a new habitat.

The disease is characterized [2] by a dying of the cane tops, a rotting of the tissues at the base of the "arrow," and the production of a yellowish gummy substance in the bundles of the stem. Gumming is propagated through diseased sets. The bacterial organism advances in the bundles of the stem along with the growing plant. In severe cases the plants are dwarfed, attaining in a year's growth only a third or half the size of healthy plants. Occasionally the young plants are killed before they have had time to push through the ground. If a diseased stalk is cut crosswise, a sticky yellowish sub-

[1] Cobb, N. A. Diseases of the sugar-cane. Agricultural Gazette of New South Wales, v. 4, pt. 10, p. 777–833, 46 fig., 1893.

[2] Cobb, N. A. Third report on gumming of the sugar cane. Report of Work of the Experiment Station, Hawaiian Sugar Planters' Association. Division of Pathology and Physiology, Bulletin 3, 46 p., 12 fig., 2 pl., 1905.

stance exudes from the bundles in the form of tiny drops. (See fig. 3.) This is the most characteristic symptom of the disease. Ordinary inspection, however, is not sufficient to detect this disease in cases where the cane is only slightly attacked.

Control.—Selection of cuttings and growing of resistant varieties are recommended.

SMUT.

Smut (*Ustilago sacchari* Rabenhorst) is rather widely distributed in cane-growing countries, but usually does little damage. Mr. Butler describes the disease as follows:

> Affected plants are known by the production from the growing apex of a long whip-like dusty black shoot, often several feet in length and much curved on itself. (See fig. 4.)
>
> This shoot is an entirely abnormal growth, devoid of leaves, slender, and flexible. It must probably be taken to represent an abnormal floral shoot. In its earlier stages it is covered by a silvery white thin sheath which soon, however, ruptures, exposing a dense black dust consisting of the spores of the fungus.
>
> From the upper portion of the affected cane no secondary shoots arise, but from its lower part they are fairly abundant, being all in their turn attacked and prolonged into spore-containing organs. In this way it becomes evident that the whole plant is affected.
>
> The tissues of the cane below the abnormal shoot contain the filaments of the smut fungus. These are found between the cells, not in them, as is the case with *Colletotrichum falcatum*. Diseased canes are poor in sugar and worthless.[1]

FIG. 3.—Gumming disease of sugar cane, showing gummy exudations on cut surface of cane. (After Cobb.)

The disease may be transmitted through spores coming in contact with healthy plants or through diseased sets. The latter means is probably the most frequent.

Control.—Care should be exercised to prevent the spread of spores through tools, clothing, packing, manure, etc., and only cane from healthy plants should be used for the sets.

SEREH.

The cause of sereh is unknown, although it has been recognized as far back as 1882 in Java, where it has done much damage.[2] Dr. Lyon reports it to be of rare occurrence in the Hawaiian Islands, having been first recorded in 1908.

[1] Butler, E. J. Op. cit.

[2] Deerr, Noël. Cane Sugar. Altrincham (Manchester), p. 145-147, fig. 72, 1911.

Mr. Noël Deerr states that—

In the typical form of "sereh" the stool of cane consists of a number of short stalks with very short joints; the buds, especially those below, sprout, whereby results a bundle of short stems hidden in a mass of leaves. The whole stool bears a resemblance to lemon grass (*Andropogon schoenanthus*), the Javanese term for which is "sereh." In a second type one or two stalks may grow to a fair size with very short joints in the upper part; above all is a fan-shaped leaf crown; many of the eyes, especially those below, sprout and form small branches. * * * A red coloration of the fibrovascular bundles is a characteristic of "sereh." This coloration is most pronounced in the node, but often appears in the internode in the form of a red stripe. This appearance is quite distinct from the red patch with white center characteristic of the red-rot of the stem.

A point of great interest with this disease is the difference of opinion as to its infective nature. The disease certainly spread from district to district in Java, but, conversely, healthy sticks planted in an affected field remained healthy. Whether infectious or

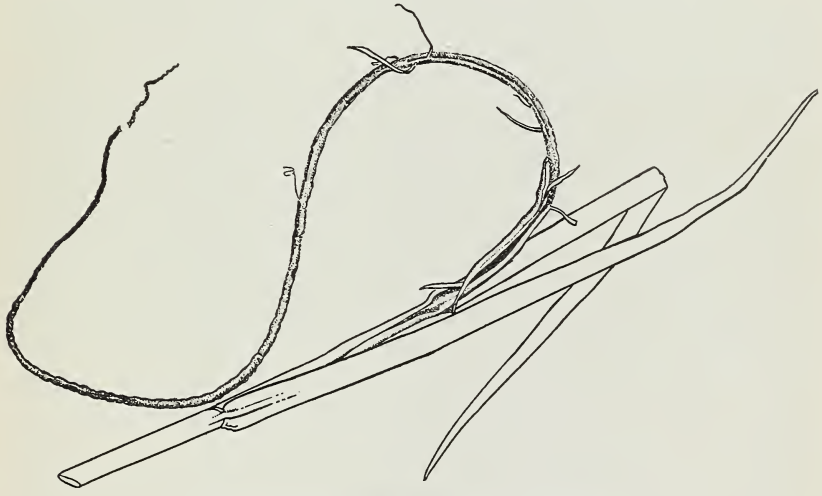

FIG. 4.—Smut disease of sugar cane. (After Butler.)

not, the disease was found to be hereditary; that is to say, canes planted from sound, healthy seed gave healthy canes, but tops derived from sereh-struck canes became equally infected.

THE PINEAPPLE DISEASE.

The pineapple disease (*Thielaviopsis paradoxa* (De Seyn.) V. Höhn) was first studied by Dr. Went in Java in 1893. Since that time it has been found also in Mauritius, British Guiana, the West Indies, Hawaii, and was reported from Louisiana in 1910. Mr. Butler reported that up to 1906 he had found the pineapple disease in Bengal on only three occasions and these were on cane which had been imported from Java and Mauritius for seed. This disease is one which chiefly attacks the planted cuttings, the fungus being a wound parasite. Considerable damage is caused wherever this disease is

prevalent through a failure of the "eyes" to germinate. Dr. Cobb considers the pineapple fungus to cause the decay of more cane cuttings in Hawaii than that produced by any other one cause and has estimated that in diseased fields the loss varies from 1 to 25 per cent of the plantings. Fortunately the disease has not become widely distributed in the United States, having only been reported from a few localities in Louisiana.[1]

The fungus effects an entrance into the cane at the cut ends of the "seed" or at any point along the stalks through wounds of the rind made either by mechanical or insect injury. The disease (fig. 5), marked by pink or red streaks, progresses rapidly through the central tissues of the cane, eventually killing the buds and thus preventing germination. Later, this central diseased tissue turns dark and finally sooty black through the production of macroconidia. This blackened central tissue is what is known as the "pipe" [2] and is one of the chief characteristics of the disease.

It is in the younger stages of the disease that the pineapple odor may be detected, being more noticeable in some varieties of cane than in others. These two characters, viz, the "pipe" and the pineapple odor, are the chief marks by which the disease may be detected. The same fungus causes a disease of pineapples.

Control.—Destruction of diseased cane and the immersion of the cuttings in Bordeaux mixture shortly after the cane is cut are recommended. In the West Indies Howard also recommends that the ends of the cane be dipped in tar as a further preservative.

SCLEROTIUM DISEASE.

The Sclerotium disease (*Sclerotium rolfsii* Sacc.) is one which attacks the leaf sheaths principally, being usually confined to the lower sheaths. It was reported from Louisiana in 1908 and has since been found in Georgia. The amount of damage caused is somewhat questionable, some claiming that it is confined to the sheaths and does very little harm, while others assert that the fungus penetrates into the stalk for some little distance and also into the bud, preventing its germination when used in plantings. This disease is probably the same as that described by Krüger [3] under the name of red-rot of the leaf sheath and stem and attributed by him to *Sclerotium* sp. He states that the disease is characterized by a brick-red discoloration

[1] Edgerton, C. W. Some sugar-cane diseases. Louisiana Agricultural Experiment Station, Bulletin 120, 28 p., 12 fig., 1910.

[2] Cobb, N. A. Fungus maladies of the sugar-cane. Report of Work of the Experiment Station, Hawaiian Sugar Planters' Association. Division of Pathology and Physiology, Bulletin 5, 254 p., 101 fig., 7 pl., 1906.

[3] Krüger, Wilhelm. Das Zuckerrohr und Seine Kultur. Magdeburg and Wien, p. 459–464, pl. 14, fig. 2–3, 1899.

of the sheath, which does not have a definite border. Later, the discolored tissue near the center takes on a blackish, sooty tinge.

The Sclerotium disease enters the stem through the bundles at the point of attachment of the leaf and then advances both above and below the node, frequently forming cankers on the stem. (See fig. 6.) Infection rarely, if ever, takes place at the internodes. If

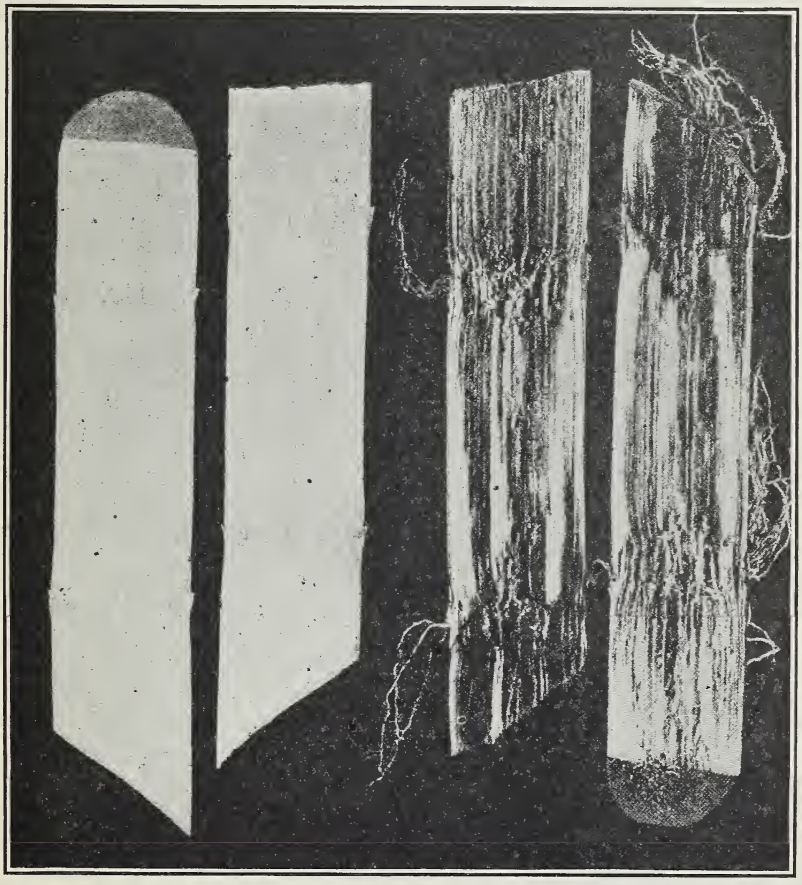

FIG. 5.—Pineapple disease of sugar cane. The cutting at the right was completely ruined in a few days, although its condition when planted was like that of the sample shown at the left. (After Cobb.)

the attacked leaf sheath is pulled off there may be seen a network of fine white shiny threads of the fungus at the base of the sheath. Later, the sclerotia, or resting stage of the fungus, consisting of small round bodies, at first white, then light yellow, and finally brown, are formed. These sclerotia remain in the tissue of the cane or drop off on the ground and are capable of carrying the fungus through conditions unfavorable for its growth, such as dryness. Under favorable

conditions, usually in the spring, these bodies produce the mycelium, which may penetrate those leaf sheaths with which it comes in contact. The disease flourishes during damp weather.

Control.—Removal and burning of the lower leaf sheaths and leaves are recommended. Infected cuttings should not be used for plantings. Krüger states that if infected cuttings come up at all they seldom produce well-developed plants.

FIG. 6.—Sclerotium disease of sugar cane, showing darkened, sunken areas below the nodes.

ROOT DISEASE.

Root disease is probably present in all the sugar-cane regions of the world. It is commonly caused by one of the following fungi: *Marasmius plicatus* Wakker, *M. sacchari* Wakker, or *Ithyphallus coralloides* Cobb. Great losses have been sustained from this trouble. Dr. Cobb[1] estimated that in Hawaii failures frequently amounted to 25 per cent and in a few cases as high as 50 or 60 per cent, while a conservative estimate was placed at 10 per cent of the ratoon crop and a somewhat smaller loss on the plant crops. In Louisiana Prof. H. R. Fulton[2] states:

> It is a usual thing to find the purple plant cane affected to the extent of 5 to 8 per cent of the stalks, and purple first-year stubble, 12 to 18 per cent. In the case of D 74, 1 to 3 per cent and 4 to 8 per cent are usual figures for the corresponding crops. Some of the worst fields seen have been in purple cane and have had 90 or 95 per cent of the stalks infected. These figures are not to be taken as representing in any way the loss due to the root disease. Affected canes, although usually small and light, are by no means a total loss; and the figures do not take into account the gaps in stands and the reduction in number of canes per stool that make up the large loss from root disease.

[1] Cobb, N. A. Op. cit.

[2] Fulton, H. R. Root disease of sugar cane in Louisiana. Louisiana Agricultural Experiment Station, Bulletin 100, 21 p., 8 figs., 1908.

The organisms causing root-rot are wound parasites, usually living a saprophytic life in the soil. When the cane is weakened from any cause, such as drought, poor cultivation, etc., the fungus can make an entrance into the roots. The root first shows a reddening of the surface, followed by a brown discoloration, and finally a slow disintegration. Plants so affected are weak and dwarfed and easily blown over by the wind or uprooted. The lower leaf sheaths are frequently enveloped in a white weft of fungous threads which cement them tight to the stalk. The disease is much more prevalent on ratoon crops than on planted cane, as it lives and grows on the stubble year after year. On planted cane the fungus envelops the stalk and soon smothers the buds, thus preventing germination and resulting in a poor stand.

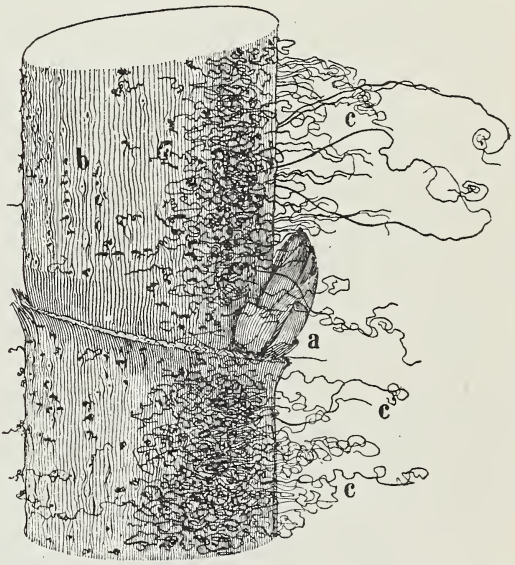

FIG. 7.—Rind disease of sugar cane, showing long, black threads of spores at "c." (After Cobb.)

Control.—Dr. Fulton suggests the following preventive measures: (1) Careful cultivation, (2) selection and disinfection of seed cane, (3) planting of resistant varieties, (4) destruction of infected trash, and (5) rotation. So far as known, no other crop is affected by root disease except sweet potatoes.[1] This has been reported from Barbados, St. Lucia, and Antigua, of the West Indies.

RIND DISEASE.

Rind disease (*Trichosphaeria sacchari* Massee) was once held to be the cause of a great amount of damage in the West Indies and elsewhere. More recently the rind fungus has been considered by various investigators to be a secondary factor appearing only after the cane has been weakened from some cause or following some parasite such as the red-rot organism. The fungus causes little damage other than hastening the complete destruction of already diseased cane. (See fig. 7.)

[1] South, F. W. Disease of sweet potatoes. West Indian Bulletin, v. 11, No. 2, p. 82, 1911.

[Cir. 126—B]

THE WORK OF THE YUMA EXPERIMENT FARM IN 1912.[1]

By W. A. Peterson, *Farm Superintendent, Office of Western Irrigation Agriculture.*

INTRODUCTION.

The Yuma Reclamation Project is characterized by climatic conditions peculiarly favorable to the production of a great variety of crops. The rainfall of the region averages only about 3 inches a year and is not a factor in crop production. The climate is warm during most of the year, the temperature for a period of 35 years ranging from a minimum of 16° to a maximum of 120° F. These conditions are specially favorable to such crops as cotton, alfalfa and alfalfa seed, figs, dates, sweet potatoes, and other crops which require a warm climate and which are well suited to intensive culture.

Since the establishment of the Yuma Experiment Farm (fig. 1) on its present site in 1909, experiments have been conducted with a

Fig. 1.—View of buildings on the Yuma Experiment Farm.

view to improving the cultural methods applicable to the above-named crops, to finding superior varieties, and to breeding superior strains of the varieties under test. Much of this work is done in cooperation with other offices of the Bureau of Plant Industry. The offices concerned in the cooperative work in 1912 are the following: The Office of Crop Physiology and Breeding Investigations

[1] Issued May 10, 1913.

The Yuma Experiment Farm is located on the Yuma Reclamation Project, 7 miles north of Yuma, Ariz., and adjacent to Bard, Cal. It consists of 160 acres of land, all of which is irrigable. The land was withdrawn from entry in 1909 by the Department of the Interior to be used as an experiment farm. Operations on the tract were begun in the spring of 1910. A farmhouse and an office building were constructed by the Reclamation Service; a tool house and a machine shed have been built by the United States Department of Agriculture. (See fig. 1.) The farm is under the direct supervision of a superintendent detailed from the Office of Western Irrigation Agriculture, Bureau of Plant Industry, and that office furnishes the funds necessary to maintain the farm. On January 1, 1913, Mr. R. E. Blair succeeded Mr. Peterson as farm superintendent.

cooperates in the work with figs and dates; the Office of Foreign Seed and Plant Introduction in the work with bamboo, carobs, etc.; the Office of Acclimatization and Adaptation of Crop Plants and Cotton-Breeding Investigations in cotton acclimatization; the Office of Alkali and Drought Resistant Plant Investigations in breeding Egyptian cotton; the Office of Corn Investigations in testing corn varieties; the Office of Cooperative Cotton Handling and Marketing and Paper-Plant Investigations in the work with ramie; the Office of Fiber Investigations in the experiments with hemp; and the Biophysical Laboratory in the climatological observations.

CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

In Table I the climatological observations made at the experiment farm in 1912 are briefly summarized, together with a statement of the average weather conditions during the three years 1910 to 1912, inclusive.

TABLE I.—*Summary of the climatological observations at the Yuma Experiment Farm, 1910 to 1912, inclusive.*

PRECIPITATION (INCHES).

Item.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average for 3 years, 1910 to 1912	0.22	0.37	0.48	0.18	0.25	0.17	0.37	0.05	0.19	0.35	0.26	0.003	2.886
For the year 1912	0	0	.89	.26	.75	.51	.20	.13	0	.33	0	.01	3.08

EVAPORATION (INCHES).

Average for 3 years, 1910 to 1912	3.42	4.48	6.92	6.58	10.8	11.25	10.29	10.31	8.27	6.47	4.46	3.41	86.66
For the year 1912	3.96	5.30	7.71	6.40	9.0	10.14	9.44	9.00	7.63	5.61	4.19	2.86	81.24

DAILY WIND VELOCITY (MILES PER HOUR).

1910, highest	.....	.....	.....	.....	9.0	8.8	7.4	7.2	4.6	9.2	6.3	6.4	.....
1911, highest	7.4	8.5	5.4	9.2	8.1	6.3	6.0	3.2	4.1	6.7	10.1	9.9	.....
1912, highest	5.4	7.4	9.3	8.4	6.9	4.4	5.1	5.9	4.7	7.9	11.4	10.8	.....
1910, lowest	.....	.....	.....	.....	2.3	1.1	1.5	2.0	1.2	.8	1.7	1.8	.....
1911, lowest	.8	.8	1.3	1.5	1.9	1.4	1.3	0	1.1	.8	1.0	1.3	.....
1912, lowest	1.5	1.1	1.4	1.7	1.5	1.0	1.5	1.2	.3	1.2	1.3	.8	.....
1910, average	.....	.....	.....	.....	4.1	3.8	3.6	3.4	2.4	3.7	3.3	3.5	.....
1911, average	3.0	3.5	2.7	3.8	3.3	2.9	2.5	2.0	1.7	2.5	3.7	3.5	.....
1912, average	3.2	4.0	3.9	3.8	3.3	2.6	2.3	2.3	2.1	3.0	2.9	4.0	.....

TEMPERATURE (°F.).

Absolute maximum:													
3 years, 1910 to 1912	84	88	94	106.5	120	117	116	113	116	107	94	81	120
For 1912	84	88	87	91	103	114	109	111	107	95	88	75	114
Absolute minimum:													
3 years, 1910 to 1912	18	27	32	35	42	47	54	61	51	36	28	16	16
For 1912	18	27	32	36	42	54	58	61	51	36	34	23	18
Mean:													
3 years, 1910 to 1912	54.1	54.6	61.5	69.0	73.6	81.6	88.0	88.3	82.3	70.2	60.1	51.1	69.5
For 1912	53.5	56.4	59.2	65.1	72.3	82.7	85.8	85.8	78.5	68.5	59.7	51.0	68.0

TABLE I.—*Summary of the climatological observations at the Yuma Experiment Farm, 1910 to 1912, inclusive*—Continued.

KILLING FROSTS.

Years.	Last in spring.		First in autumn.		Frost-free period.
	Date.	Minimum temperature.	Date.	Minimum temperature.	
		°F.		°F.	*Days.*
1910			Nov. 27	32	
1911	Feb. 24	32	Nov. 14	32	262
1912	Mar. 31	32	Dec. 4	31	247

CROP CONDITIONS.

The crop conditions on the project were generally favorable during the year 1912. In the early part of June the flood waters of the Colorado River caused some damage from seepage on the lands near the river, and some parts of the project were damaged by the rise of underground water from the river and from the excessively irrigated higher lands. The areas seriously affected by these difficulties comprise, however, only a small part of the project and the conditions on these areas are being improved by the construction of a large drainage ditch.

The total irrigable area of the farms on the project in 1912 was 27,592 acres, included in 470 farm units. Of this area, 13,767 acres were actually irrigated, and crops were harvested from 11,060 acres. The acreage, yields, and farm values of the crops on the project in 1912 are stated in Table II. The figures were obtained from the United States Reclamation Service.

TABLE II.—*Acreage, yields, and farm values of crops grown on the Yuma Reclamation Project in 1912.*

Crop.	Area.	Unit of yield.	Yield.			Farm value.			
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.	
				Average.	Maximum.			Average.	Maximum.
	Acres.								
Alfalfa hay	7,269	Ton	27,078	3.73	10.00	$10.00	$270,780.00	$37.30	$100.00
Alfalfa seed	2,824	Pound	814,186	288.00	900.00	.10	81,418.60	28.80	90.00
Alfalfa straw[1]	2,824	Ton	3,000	1.06	2.00	5.00	15,000.00	5.30	10.00
Barley hay	208	do	416	2.00	2.50	9.00	3,744.00	18.00	22.50
Grain sorghum	986	Bushel	31,372	31.80	100.00	.75	23,529.00	23.85	75.00
Wheat and barley[2]	1,567	do	55,357	35.30	60.00	.75	41,517.75	26.47	45.00
Corn	294	do	6,602	22.50	40.00	.75	4,951.50	16.87	30.00
Cane	292	Ton	1,252	4.30	8.00	5.00	6,260.00	21.50	40.00
Cotton	25	Pound	5,800	232.00	500.00	.20	1,160.00	46.40	100.00
Truck crops	431						19,902.00	46.30	
Pasture	575						28,750.00	50.00	
Less duplications	5,735								
Total	11,060						497,012.85		
Average value								44.94	

[1] "Alfalfa straw" is the residue left after the alfalfa seed is removed from the plants. Its farm value on the Yuma Project in 1912 was estimated at one-half that of alfalfa hay.

[2] The yield and farm values of these grains were not segregated in the reports made by the Reclamation Service.

CROP EXPERIMENTS.

The experiments conducted at the Yuma Experiment Farm in 1912 included chiefly alfalfa, cotton, corn, dates, figs, and truck crops. The arrangement of the fields and the location of the crop experiments in 1912 are shown in figure 2. Cultural experiments were conducted with these and with some miscellaneous crops, and

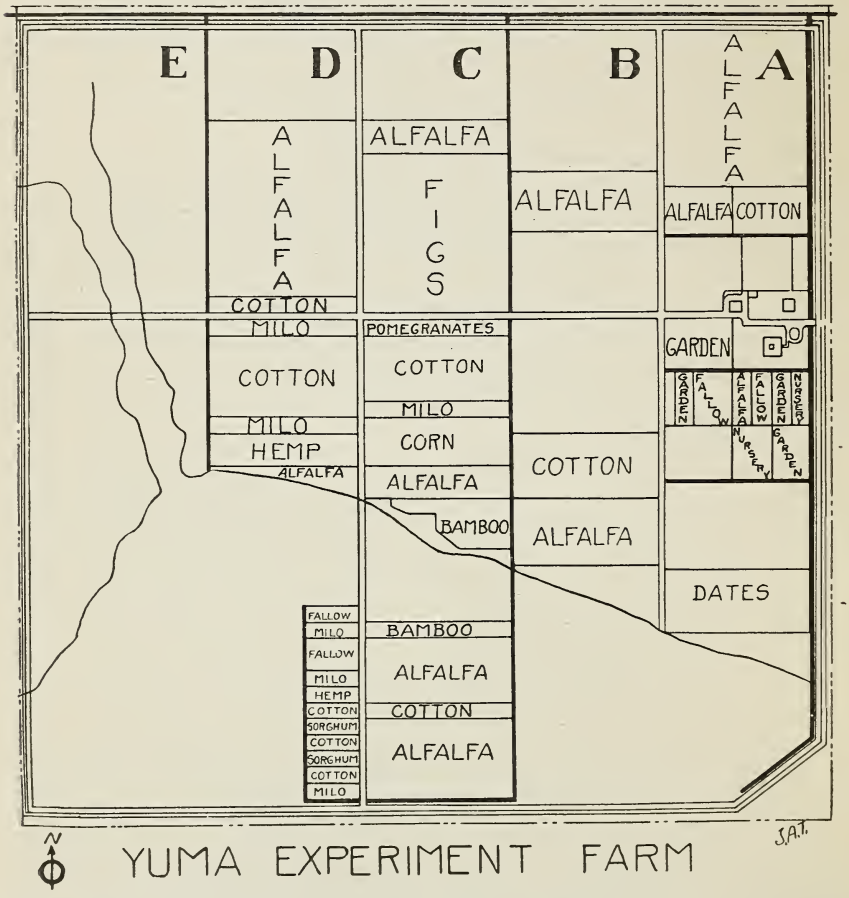

FIG. 2.—Diagram of the Yuma Experiment Farm, showing the arrangement of the fields and the location of the experiments in 1912.

some variety testing and breeding work was done with corn, cotton, dates, and figs. Most of the experimental work was a continuation of work started in previous years, and the following brief discussions of the different crops are based on the results obtained at the experiment farm, not only in 1912 but to some extent in previous years as well.

ALFALFA.

Alfalfa is the most important crop grown on the project. Failure to secure a perfect stand by the usual method of broadcast seeding often enables Bermuda grass to secure a foothold and ultimately crowd out the alfalfa. The experiments conducted at the experiment farm in starting alfalfa have indicated that the methods described below can be expected to result successfully. It has been found that fields planted with a grass-seed drill or a grain drill with a grass-seed attachment usually produce a uniform stand. It is important that the land be first properly leveled and the grade on the fields made not to exceed 1 inch to 200 feet. After plowing, a thorough irrigation is given. The soil is cultivated as soon as possible after irrigation, in order to form a loose soil mulch. Spike-tooth and disk harrows are excellent implements for this purpose. Soon after the preparation of the seed bed the seed is planted sufficiently deep with a drill, so that all seed are deposited in the moist soil directly underneath the mulch. When alfalfa is planted with a drill, 8 to 10 pounds of first-grade seed are ample, while 12 to 20 pounds per acre are necessary when the seed is broadcasted. The most favorable planting season is between September 15 and October 15. When planted at this time, alfalfa becomes well rooted before cold weather, and it is not troubled so much with weeds the following spring, as is the case with spring-seeded alfalfa. Where the soil is very sandy it is necessary to irrigate after planting in order to secure proper germination.

The heaviest yields of alfalfa seed are frequently obtained from fields badly infested with Bermuda grass. This appears to be due to the fact that the plants produce seed better when they are far enough apart to be fully exposed to light. From these observations, as well as from results obtained from planting alfalfa in rows 24 to 30 inches apart where the plants have seeded abundantly, it has seemed desirable to try various methods of row planting for the purpose of seed production. Field plantings in rows varying from 18 to 40 inches apart have been made in order to determine the value of this method.

The sandier lands on the project are relatively unproductive at first. The first aim of the farmer should be to increase the fertility by the addition of silt and organic matter. Alfalfa is an exceptionally valuable crop for this purpose. It is irrigated by flooding, and consequently the silt in the irrigation water is deposited uniformly over the field. The decayed roots that remain after plowing alfalfa land, as well as the surface accumulation of leaves, materially increase the humus content of the soil. The sandy areas in spotted fields are

readily indicated by the poor growth of alfalfa. Manure or other fertilizer can be applied to these areas until their fertility is equal to that of the remainder of the field.

BERMUDA GRASS.

Bermuda grass, an introduced plant, has proved an exceptionally troublesome weed. In the Southern States, where it does not produce seed, it is considered a valuable forage grass, but in the vicinity of Yuma it produces seed abundantly. It generally covers the ditch banks, and as a consequence the seeds fall into the irrigation water, which acts as an effective distributing agent. Bermuda grass makes an excellent pasture, but is far inferior to alfalfa for this purpose.

On account of its tenacious character, the grass is difficult to eradicate when it once acquires a foothold in a field. The best method of killing it so far found has been to give a thorough shallow plowing during the summer months, followed by an occasional disking in order to cut up and dry out the furrow slice. This method has been used successfully on the experiment farm. A strong moldboard plow having a cutting edge on the land side is a useful implement for turning over Bermuda-grass sod. If the work is well done, a clean field can be had by fall. It is essential that all irrigation water be kept off the land while this treatment is being applied. If the eradication is not complete, the land can be irrigated late in the fall and a crop of small grain grown, since Bermuda grass does not grow during the winter months. If the eradication has not been complete, the process should be repeated the following summer. The cultivation given to a growing crop of cotton has also been found very effective in Bermuda-grass eradication.

Bermuda grass will grow where the underground water during the flood stage of the Colorado River comes practically to the surface, a condition disastrous to most other crops. It also withstands a rather high alkali content in the soil, and on account of the rapidity with which it spreads when it once secures a scattered foothold it should prove useful in reclaiming alkali areas. On such areas, where alfalfa does not do well, Bermuda grass has a distinct value as a pasture crop, since the forage is highly nutritious and the plants very resistant to the effects of close grazing.

COTTON.

For several years much emphasis has been placed on cotton work in an effort to develop varieties adapted to the climatic conditions of the arid Southwest. The high price which Egyptian cotton commands and the similarity of the conditions in the irrigated sections

of the Southwest to those of the Nile Valley led the Department to believe that Egyptian cotton could be successfully grown in the southwestern United States. Several years of breeding and selection carried on at the experiment farm by the Office of Alkali and Drought Resistant Plant Investigations have resulted in the production of improved varieties of Egyptian cotton. Seeds of one variety, known as the Yuma cotton, have been distributed to farmers in southern Arizona and California. An area of 550 acres was devoted to the production of the improved varieties of Egyptian cotton in the Imperial, Yuma, and Salt River Valleys during 1912.

In addition to the breeding and extension work with Egyptian cotton, extensive experiments along cultural lines have been carried on at the Yuma farm by the Office of Acclimatization and Adaptation of Crop Plants and Cotton-Breeding Investigations. It has been demonstrated that cotton can be reproduced from mature wood cuttings and that cotton plants can be volunteered by protecting the bases of the stems with soil during the winter.

A large number of hybrids between Egyptian and Upland cottons have been made and grown and different methods of making such hybrids have been studied. Many of these hybrids produce fiber of a very superior quality. A number of varieties of Upland cotton have been tested.

During the season of 1912 two stands of roller gins were installed at the experiment farm. These were placed at the disposal of the local farmers in ginning the 1912 crop.

CORN.

Although corn has not yet proved a profitable crop on the irrigated lands of the Southwest, it has seemed advisable to try a number of varieties not commonly grown in the region. The yield is low and often the crop is a complete failure, due to high temperatures or dry winds at blossoming time. The corn worm is also quite injurious. A large number of varieties have been tested in cooperation with the Office of Corn Investigations, but nearly all have been discarded. In 1912, 22 varieties and selections were tested, but the results were not encouraging. Selection 157, a strain of Laguna corn, appears to be better adapted to the climatic conditions than any other variety grown at present. It has an exceptionally tough husk, which greatly reduces the worm injury. Corn yields have varied from 25 to 48 bushels per acre.

DATES.

The Yuma Project is included in the limited area in the southwestern United States where dates can be successfully grown. Large quantities of the date seed have been distributed to settlers on the

project and considerable assistance has been given in encouraging the industry. Three thousand seedlings of desirable varieties have been planted on the farm, from which some excellent new varieties may be expected. The seedling dates include a row that was planted around the farm for ornamental purposes. Offshoots from 15 varieties of imported palms have been planted, and additional varieties will be planted as fast as they become available from other stations. Some difficulty has been experienced in getting transplanted offshoots to grow. The difficulty has been largely overcome by planting the offshoots (fig. 3) in soil having good drainage and then irrigating every other day during the summer months. Date offshoots seem to

FIG. 3.—View showing method of rooting date-palm offshoots in nursery rows on the Yuma Experiment Farm.

require that the immediately surrounding soil shall constantly be in a nearly saturated condition. Under this treatment the percentage of offshoots that do not root has been greatly decreased.

FIGS.

The soil and climatic conditions on the Yuma Project are well adapted to fig culture. Figs of good quality can be placed on the market early in the season. The Smyrna is the best fig that is marketed at the present time. In contrast to the common varieties of figs, which are self-pollinated, the Smyrna fig is cross-pollinated through the agency of a small insect. The requirements necessary to carry this insect through the winter and to insure its presence in

sufficient numbers at the right time in the spring are a serious handicap to the rapid extension of the Smyrna fig industry. It is highly desirable that a fig be originated that will have the excellent qualities of the Smyrna, but which, like the common varieties of figs, will set fruit without insect pollination. More than a thousand seedlings, crosses between the Smyrna and common varieties of figs, have been planted in orchard form (fig. 4) with the hope of securing some new varieties having the above-named desirable characteristics. These seedlings will begin to bear during the season of 1913.

The minimum of 16° F. above zero during the winter of 1911–12 killed nearly all the seedling figs to the ground. Since equally low temperatures may occur at intervals of 10 or 15 years, it is desirable

FIG. 4.—View in the fig orchard on the Yuma Experiment Farm. More than a thousand seedlings, crosses between the Smyrna and common fig varieties, are being tested.

that the new wood on fig trees shall be well ripened before cold weather sets in. This was accomplished at the experiment farm during the season of 1912 by withholding irrigation water from the fig orchard from about the first of August and thus preventing late growth.

VEGETABLES.

A garden for supplying the farm cooperative mess with fresh vegetables has been grown each year. Most of the varieties of vegetables that are recommended by reliable seed houses for planting in the Southwest have been successfully grown when planted during the proper season. There is no good reason why a farmer on the Yuma Project should not have fresh vegetables from his own garden the entire year. Varieties of tomatoes, such as the Dwarf Champion, that have the fruit shaded by dense foliage, are the most satisfactory.

Irish potatoes have not been extensively grown, partly on account of the frequent failures due to improper cultural methods. On the experiment farm this crop has been very successful when properly handled. It has been found that medium sandy soil is best, particularly if it is old alfalfa sod. The land is thoroughly irrigated early in January and plowed as soon after irrigation as possible. The potatoes are planted between January 15 and February 1 in rows 2½ or 3 feet apart, with the tubers 12 to 16 inches apart in the row. It has been found desirable to harrow the soil frequently and to withhold irrigation water until the plants are about to bloom. One light furrow irrigation at the time of blooming, followed by cultivation, is usually sufficient to mature the crop. If irrigation water is kept off the field after the crop reaches maturity the tubers can be harvested as wanted for a period of six weeks.

EUCALYPTUS.

The protecting levees on either side of the Colorado River are 4,000 feet apart. About 1,000 feet of this space is occupied by the river channel. The remainder of the area between the levees is subject to periodic overflows. It is desirable that as much of this land as is not occupied by the river channel shall be covered with timber. It is now covered with cottonwood and willow, neither of which is particularly valuable. It has seemed probable that some of the species of eucalyptus might prove well suited to the situation and serve somewhat to hold the river to its channel and at the same time furnish useful timber.

In 1910, 100 plants of eucalyptus, including the red, gray, and desert gums, were planted on this overflow land. All three of the species have done well, notwithstanding a 3-foot overflow and extremes in temperature varying from 16° to 120° F. The red and gray gums have attained a height of 24 feet and the desert gum a height of 20 feet. These trees have had to compete with the rank growth of native vegetation, consisting of cottonwood, willow, and arrow weed.

There are many waste areas on the project that could be profitably planted to eucalyptus. On account of their deep-rooting habit, these trees obtain their moisture from the underground water and are not dependent on irrigation. Every farmer would find it advantageous to plant an acre or two if for no other purpose than to supply fence posts and fuel. The eucalyptus trees are also desirable for ornamental purposes. A row of the desert gum has been planted around the experiment farm.

MISCELLANEOUS CROPS.

In 1912 half an acre was planted to hemp in order to determine the possibilities for hempseed production on the irrigated lands of the Southwest. The soil was lacking in uniformity. On the spots of medium and heavy soils the hemp attained a height of 10 to 20 feet and seeded abundantly. The seed was harvested, but at the time of writing it had not been sufficiently cleaned to give yield-test weights.

On account of the rapidity of growth of bamboo and the innumerable uses to which it can be put, several hundred plants of two large commercial species from the Orient were planted in nursery rows in 1911. These species have not proved hardy enough to withstand the low temperatures which occasionally occur. However, it is possible that after the plants become well established they will be sufficiently self-protecting to pass through most winters without injury. The bamboo work was extended in 1912 by a half-acre planting on low land in order to determine the adaptability of bamboo to land having a high underground water table.

The carob (*Ceratonia siliqua*), a promising introduction from Spain, is being tested. The plants were frozen to the ground in the winter of 1911–12, but they put out branches from below the ground line and made a good growth during the past summer.

PUBLICATIONS.

The following publications, based wholly or in part on experiments and observations at the Yuma Experiment Farm, have been issued by the United States Department of Agriculture:

McLachlan, Argyle. The branching habits of Egyptian cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 249, 28 p., 1912.

Cook, O. F. Results of cotton experiments in 1911. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 96, 21 p., 1912.

Kearney, T. H. Fiber from different pickings of Egyptian cotton. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 110, p. 37–39, 1913.

Kearney, T. H. Egyptian cotton as affected by soil variations. U. S. Department of Agriculture, Bureau of Plant Industry, Circular 112, p. 17–24, 1913.

Scofield, C. S. Suggestions on growing Egyptian cotton in the Southwest. U. S. Department of Agriculture, Bureau of Plant Industry, Western Agricultural Extension Circular, 10 p., 1912.

As rapidly as definite results are obtained at the experiment farm, reports will be published and distributed among the farmers on the project.

[Cir. 126—C]

DIRECTIONS FOR COLLECTING PLANTS.[1]

By P. L. Ricker, *Assistant Botanist, Taxonomic and Range Investigations.*

INTRODUCTION.

Several thousand specimens of plants are sent annually by farmers, florists, nurserymen, and amateur botanists to the United States Department of Agriculture for identification. In many cases the specimens consist of small fragments of the plants, which are not adequate for satisfactory identification and are often without data. Many of these specimens if properly prepared or packed would be valuable additions to the Department collections, but as usually received they are worthless and difficult to identify, requiring an expenditure of time entirely out of proportion to the value of the specimen or the usefulness of the information to the sender. It is with a view to the improvement of such specimens that this paper was prepared.

Most of the specimens are received from persons without a knowledge of the methods of collecting, preparing, and packing for shipment, and it is chiefly to these that the directions are addressed. Abbreviated directions are given on page 35 for those who have not the time or customary outfit for the careful preparation of specimens, but more complete directions will be given first, in the hope that all correspondents will assist in building up a valuable economic collection and materially reduce the amount of time and labor required to make identifications.

THE EQUIPMENT.

The digger.—A stout knife or garden trowel may be used for digging the plant. The most serviceable all-around tool for collecting is, however, a United States Army intrenching tool (fig. 1),[2] which is like a broad knife, the blade being $8\frac{1}{2}$ inches long, 2 inches wide, and pointed at the end. It is provided with a heavy sole-leather case in which it is held by a spring and is easily attached to a belt. As a possible

[1] Issued May 10, 1913.

[2] Shown with case and hook for attaching to a belt, in the left foreground of the illustration. These can be obtained from dealers in second-hand Army equipment at a cost of about $1 each.

addition, the amateur or professional collector will find a light pick [1] very serviceable in a rocky soil. This is about 10 inches long and constructed similar to a mattock, but with one end pointed like a pickax and weighing only about $1\frac{1}{4}$ pounds in addition to the handle. If the pick is made by a blacksmith, he should be instructed to forge the shank into which the handle is wedged not less than $1\frac{1}{2}$ inches in length.

The collecting case.—For those who are collecting plants in the field two methods are available, a third method, that of carrying a press and driers and putting the plants in as collected, being discarded by most of the experienced collectors. First, for short trips on which it

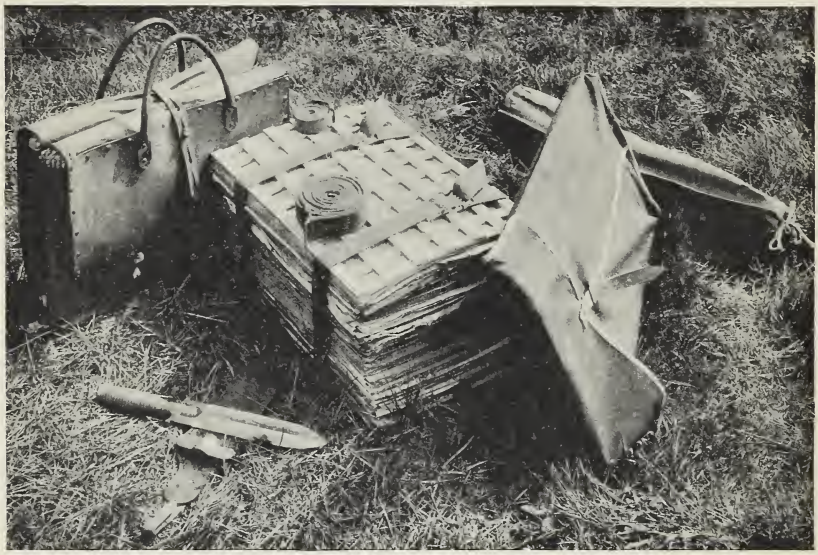

FIG. 1.—A collecting portfolio, bundle of plants in press, plant digger and case, and folding stove used in drying plants, with collapsible smokestack in canvas carrying cases.

is expected to obtain only a few plants a collecting box may be used. This is made of tin and is cylindroid in form, with a cover hinged on the side, and is carried by a strap attached at the ends.

For more extended trips or one on which it is expected to obtain a large number of specimens some form of collecting portfolio is preferable. (Fig. 2.) A very satisfactory one may be constructed from two pieces of heavy binder's board or leather board, measuring 12 by 17 inches. To the long edge (the back) of one, near each end, should be riveted a buckle, and to the corresponding portion of the other board should be riveted two straps about 6 inches long. Thus, the two parts when buckled together have a back adjustable to the number of specimens obtained. To the middle of the upper side of one

[1] These can be obtained from botanical supply companies at a cost of about $1.75 each.

cover should be riveted another strap, which may be put through a buckle fastened to the corresponding point on the other cover, to keep the covers together. A much more convenient fastening for the strap, however, is a button, similar to that by which the curtains are fastened on a carriage. Short slits to go over the button should be cut in the straps at intervals, doing away with the inconvenience and waste of time involved in fastening and unfastening a buckle. A few inches on either side of the middle strap and its fastening should be fastened the ends of a leather handle. Such a handle should be attached to each cover, so that the two can be used in temporarily holding the covers together. Thus, one avoids the necessity of bothering with the strap every time a plant is put in the portfolio. The portfolio covers should be sufficiently thick to avoid much warping at the corners. The warping can be largely prevented by riveting a thin strip of iron or steel about three-fourths of an inch wide to the inside

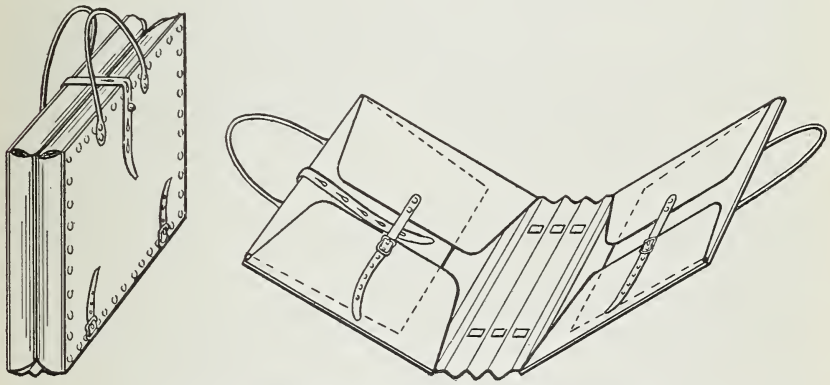

FIG. 2.—A collecting portfolio, showing plan of construction.

of the upper and lower edges of the portfolio covers. If the covers are of heavy binder's board, the total weight of the portfolio is considerable, but this may be replaced by tough fiber board, such as is used in light extension cases. The boards may be covered with enamel cloth or leather, with flaps for the protection of the specimens in rainy weather. The side flaps should be 10 inches wide and the two end ones 7 inches wide, the latter being held together by a strap.

The portfolio should then be filled with thin papers, which when folded should measure $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. Newspaper stock is best for this; in fact, ordinary newspapers cut to this size may be used with advantage. The above sizes should be maintained as a maximum in order that the resulting specimens shall not be larger than the standard mounting sheet, which is $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. The unused sheets can be kept in place and easily slid from under the flaps on one side of the portfolio as needed, the flaps on the opposite side

aiding in holding the filled sheets in position. The strap holding the filled sheets need not be fastened each time a folder is placed under them, as in carrying the portfolio short distances the handles of the portfolio give sufficient pressure to hold the specimens in place. Two portfolios may be carried if many specimens are to be obtained. They will hold all that one person can collect in a day.

The press.—The best form of press (fig. 3) consists of two slat frames, 12 by 17 inches, made from pieces of ash three-sixteenths of an inch thick and three-quarters of an inch wide, the slats to be placed about an inch apart, the ends and all intersections being fastened with

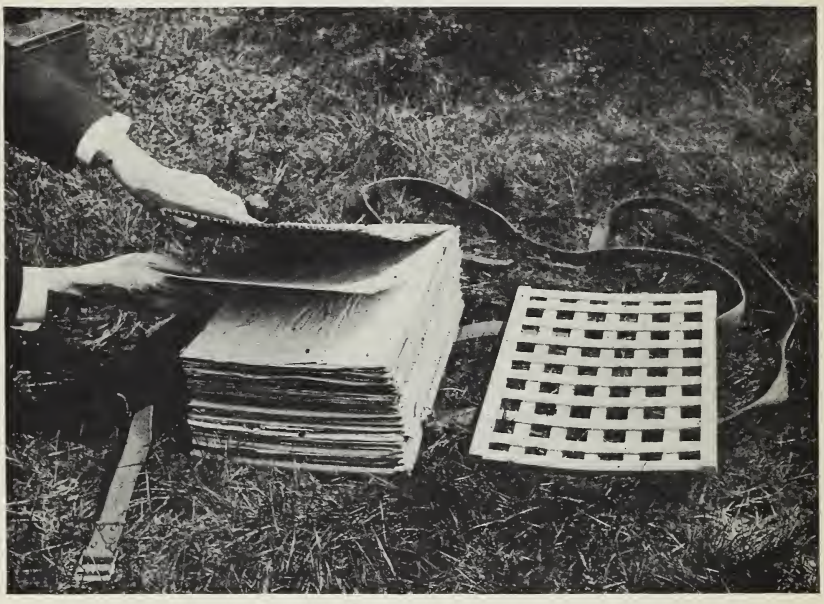

FIG. 3.—A plant press before strapping together, showing construction of the slat frames and the sheets of corrugated cardboard placed between the pairs of driers which separate the folded thin sheets containing the plants.

three or four wire brads, which should be securely clinched. Small rivets may be advantageously substituted for the wire brads in the ends of the strips of wood, since with hard usage the wire brads are more likely to pull out. The driers should be of heavy gray blotting paper or felt carpet paper, cut $11\frac{1}{2}$ by $16\frac{1}{2}$ inches. Pieces of corrugated strawboard (fig. 3), preferably with both surfaces smooth, cut to $11\frac{1}{2}$ by $16\frac{1}{2}$ inches, with the corrugations running lengthwise, placed between the blotters will be found to be of inestimable assistance in drying the plants. Two ordinary leather trunk straps may be used to secure the necessary pressure. Recent experience has, however, demonstrated that a heavy canvas trunk strap having a

buckle with a flat tongue and corrugated edge is more satisfactory than a leather strap. Solid board presses have been used, but they are more likely to cause a sweating and blackening of the plants on the outside of the bundle.

SPECIAL DIRECTIONS FOR PREPARING AND DRYING PLANTS.

Herbaceous plants.—All herbaceous specimens (i. e., those without a woody stem) that are not over 3½ feet tall should be collected entire, including root, stem, leaves, flowers, and fruit when available.

FIG. 4.—A specimen placed between thin sheets, showing the method of folding a tall plant before pressing.

When the stem of a plant is too long to go into the sheets it should be folded into 12 or 15 inch lengths, beginning at the root end to fold (fig. 4). The folds may be held together by strips of thick paper about 1 by 3 inches, with a slit in the middle, the folded ends being inserted through the slit. When herbaceous specimens are over 3½ feet tall it is rarely necessary to collect the whole plant. The height of the plant should be noted on the folder or in a notebook and placed on the label of the plant when it is mounted. Many tall specimens are too thick at the base to be collected entire. In such cases a piece

of the top of the plant about 15 inches long should be collected, together with leaves from the middle or base of the stem, showing the maximum size and any variation in shape. If the root is bulbous or thick and fleshy it should be split in the middle, and if necessary to further reduce the thickness (which preferably should not be over one-fourth of an inch) the inner portion may be scooped out with a knife. All dirt should be removed from the roots and the specimen should be laid out smoothly in one of the folders and placed under the flaps on the side of the portfolio reserved for this purpose.

Woody plants.—A branch from a woody specimen bearing leaves and flowers, or fruit when obtainable, should be about 12 to 15 inches long. Sterile shoots and suckers bearing leaves should be collected when the leaves differ from those of the flowering branches.

Aquatic plants.—Some aquatic plants will stick to the thin drying sheets so that they can not be removed without injuring the specimen. These should be placed in clean water and floated out on a piece of clean white paper that can finally be attached to the mounting sheet, placed in one of the thin driers, and the plant covered with a piece of the finest mesh white cheesecloth or unbleached cotton cloth. When dry this can with care be peeled off without injuring the specimen.

Succulent plants.—Some plants of the orpine family are very difficult to dry perfectly under ordinary conditions, and after they are apparently dried they have been known during damp weather to send out shoots while in the herbarium. This may be prevented by immersing the plant for a few seconds in boiling water to kill the tissues before it is put in the press. Fleshy plants of the cactus family may be treated in the same way if the joints are to be preserved in boxes. Excellent specimens are also made by splitting the joints laterally, scraping out the inside, and pressing the halves.

Seed.—Small quantities of seed may be collected in strong manila envelopes. For larger quantities, bags made from cheesecloth or cheap cotton cloth may be used. It is very desirable in collecting seed that a herbarium specimen from the same plant as the seed be collected to assist in a correct identification, the seed and specimens being given the same number as soon as collected. If possible the specimen should be preserved in some herbarium where it can be consulted should any question arise as to the identification of the seed.

Pressing and drying.—Upon returning from a collecting trip, the plants in the folded sheets should be put in press as soon as possible. They will, however, remain in very good condition in the portfolio as long as 12 or 18 hours. Two driers should be placed between the

folders containing the plants, and, if the plant is very fleshy, three or four driers may be used to advantage.

When the corrugated pieces of strawboard previously referred to are used, only one drier should be placed between it and the folder containing the specimen (fig. 3). The straps should then be adjusted around each end of the press and pulled up as tight as practicable without crushing the plants. Subsequent drying and contraction of the plants may release the tension of the straps and this should be readjusted once or twice during the first day or two. The press full of plants should be kept in a dry place, and, when corrugated boards are not used, the driers should be changed every day for the first three or four days, and then every other day until the plants are dry. Corrugated boards are not of much value in damp weather unless artificial heat is used for drying the plants. The damp driers when removed from the press may be dried in the sun or near a stove. When the corrugated boards are used and the press is placed in a dry sunny situation, or if artificial heat is used, the driers need not be changed at all. The specimens will be thoroughly dry in two to four days.

FIG. 5.—A folding camp stove set up and a plant press suspended above it for artificial drying.

Artificial drying.—On extended field trips much difficulty is often experienced in drying the plants during damp or rainy weather. To

avoid this difficulty a small folding camp stove [1] made of sheet iron and using wood for fuel may be used and the plant press suspended from the limb of a tree (fig. 5) or from a tripod of green saplings. The press should be 18 inches or 2 feet above the stove. These stoves can be set up inside a tent, the tent being protected from the funnel by an asbestos ring designed for this purpose by dealers in camp outfits, or in the absence of a tent a few boards or even a thatched roof can be arranged to shelter the press from rain. Stoves with liquid fuel are less satisfactory, apparently because of the amount of water vapor in the heated air, the plants drying more slowly and showing more tendency to blacken than with dry heat.

An electric heater with a round disk about 6 inches in diameter has been found satisfactory when the drying is done indoors and electric current is available. The press may then be supported on a frame, or even hung under a camera tripod and driers set on edge around the legs to aid in retaining the heat. The press can also be suspended along an ordinary cooking range, or even placed back of the range with equally good results. Care should be taken in all forms of artificial heating to prevent the plants nearest the source of heat from becoming too hot, as such heating will cause them to sweat and blacken. The position of the press should be changed occasionally, so that all sides may be equally dried. Those fearing to injure the plants by artificial heat will at least find a heating apparatus invaluable in drying the driers. In a dry, sandy, or desert region when the sun is shining the driers will dry very rapidly if laid on the ground, and in such situations it is preferable to lay the plants out on the ground between the driers when the latter are to be dried. An elastic band slipped over each end will prevent them from being blown about, and they should be turned over two or three times at short intervals. As soon as the driers are dry they should be returned to the press, to prevent the plants from becoming wrinkled.

ABBREVIATED DIRECTIONS FOR PREPARING SPECIMENS.

Those wishing to prepare only an occasional specimen to send to the Department for identification can make them of the size indicated on page 29 and press them between pads consisting of several thicknesses of newspaper. These pads should be changed daily as long as they are damp, and a board with a few bricks or heavy books may be used for a weight.

PREPARATION OF DATA.

All specimens should be accompanied by a statement showing the locality, date, and place of collecting and the collector's number.

[1] These may be obtained from dealers in campers' supplies.

The locality should be so definite that the spot can be revisited if necessary. A plan of the immediately surrounding region may advantageously be made in the notebook to aid in relocating individual plants. Notes should be made of the habit and size of the plant, particularly when the whole plant is not collected. The data should be written on the sheet in which the plants are pressed or on a temporary label provided for the purpose, or, if more convenient, the sheets may be numbered and the data all entered in a notebook at the time the specimens are collected. Specimens for identification should be prepared in duplicate, both given the same number, and one sent with full data, the determinations being returned by number. Great care should be taken that all specimens bearing the same number are specifically identical or are from the same plant, as much confusion has been caused by collectors distributing two or more species under the same number. For convenience in citation by publishing botanists, those making herbaria of their own or who are collecting plants for distribution should number all their collections consecutively from 1 upward and should not begin at 1 each year, as this often leads to confusion. A field notebook should also be kept, in which is a list of the numbers, followed by the names when the plants have been identified, the date and place of collecting, the altitude when from mountains, and the habitat and kind of soil in which they grew. Cultivated specimens should be accompanied by data as to the native country or trade firm from which the specimens or seeds were originally received. It is also important that any local or trade name should be given when known, together with any economic uses of the plant. A plain label about $1\frac{7}{8}$ by 4 inches, bearing such data as necessary, is preferable, with the region in which they were collected printed at the top, as "Plants of Arizona." If many labels are to be written, other data may be printed to save time.

SHIPPING SPECIMENS.

Pressed and dried specimens should be shipped in the thin sheets in which they were collected, and the bundle of sheets placed between pieces of binder's board or heavy cardboard and securely wrapped and tied. Where it is impracticable to make a good herbarium specimen of the plant, the specimen should be carefully wrapped in damp sphagnum moss and inclosed in oiled or paraffin paper. If these materials are not available, moistened newspapers may be used for wrapping the plants and the package then inclosed in stout wrapping paper. Packages to be sent by parcel post must not exceed 11 pounds in weight or 72 inches in length and girth combined.

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